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(54) **POLYURETHANE FOAM AND METHODS OF FORMING THE SAME**

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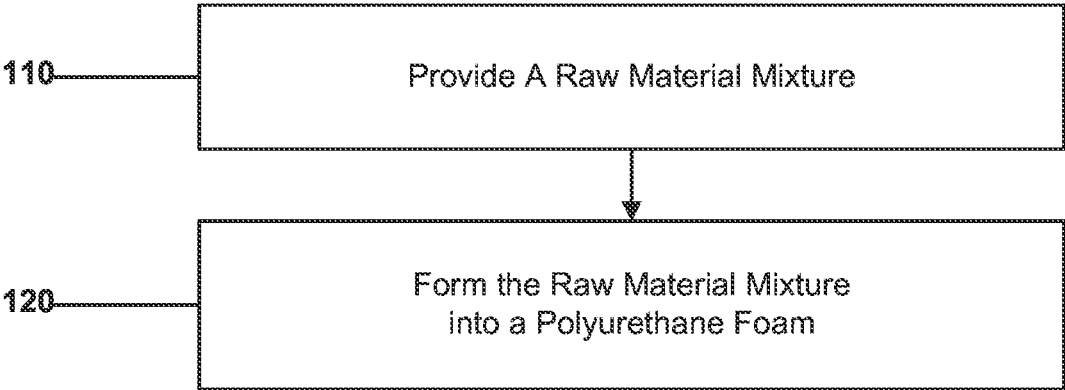
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(57) **ABSTRACT**

The subject application relates to polyurethane foam and methods of forming the same. A polyurethane foam may include a first polyol component and a second polyol component. The first polyol component may include a polyether polyol having a functionality of at least about 5. The second polyol component may include at least one component selected from the group of a polyether polyol having a functionality of not greater than about 4, and a polyester polyol having a functionality of not greater than about 4.

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POLYURETHANE FOAM AND METHODS OF FORMING THE SAME

CROSS-REFERENCE TO RELATED APPLICATION(S)

This application claims priority to Chinese Patent Application No. 202010997685.7, filed Sep. 21, 2020, entitled "POLYURETHANE FOAM AND METHODS OF FORMING THE SAME," by Qing Gao et al., which is assigned to the current assignee hereof and incorporated herein by reference in its entirety. This application further claims priority under 35 U.S.C. § 119(e) to U.S. Provisional Patent Application No. 63/089,599, filed Oct. 9, 2020, entitled "POLYURETHANE FOAM AND METHODS OF FORMING THE SAME," by Qing Gao et al., which is assigned to the current assignee hereof and incorporated herein by reference in its entirety.

FIELD OF THE DISCLOSURE

The present disclosure relates to a polyurethane foam and methods of forming the same, more particularly, the present disclosure related to a polyurethane foam having a superior flame retardancy rating and methods of forming the same.

BACKGROUND

Polyurethane foams are widely used in applications of construction, transportation, and electronics. However, such polyurethanes foams often include specific characteristics that make them prone specific safety issues. For example, such polyurethane foams are generally prone to rapid fire growth due to their inherent chemical properties (i.e., the "—NH—COO—" groups" of the polyurethane foam cause lower decomposition temperature than many other polymers) and physical properties (i.e., low density of the polyurethane causes severe dripping during combustion and porous structure promotes oxygen and heat transfer). Accordingly, polyurethane foams formulations with improved safety characteristics are desired.

SUMMARY

According to a first aspect, a polyurethane foam may include a first polyol component and a second polyol component. The first polyol component may include a polyether polyol having a functionality of at least about 5. The second polyol component may include at least one component selected from the group of a polyether polyol having a functionality of not greater than about 4, and a polyester polyol having a functionality of not greater than about 4. The polyurethane foam may have a density of at least about 150 kg/m³. The polyurethane foam may have a compression curve ratio CFD_{70}/CFD_{10} of not greater than about 20, where CFD_{70} is equal to the compression force deflection (CFD) of the polyurethane foam measured at a 70% compression ratio and CFD_{10} is equal to the compression force deflection (CFD) of the polyurethane foam measured at a 10% compression ratio.

According to a first aspect, a polyurethane foam may include a first polyol component and a second polyol component. The first polyol component may include a polyether polyol having a functionality of at least about 5. The second polyol component may include at least one component selected from the group of a polyether polyol having a functionality of not greater than about 4, and a polyester

polyol having a functionality of not greater than about 4. The polyurethane foam may have a density of at least about 150 kg/m³. The polyurethane foam may have a HBF rating based on a UL94 flame retardancy test performed at a polyurethane foam thickness of 1.0 mm.

According to yet another aspect, a method of forming a polyurethane foam may include providing a raw material mixture and forming the raw material mixture into a polyurethane foam. The raw material mixture may include a raw first polyol component and a raw second polyol component. The raw first polyol component may include a polyether polyol having a functionality of at least about 5. The raw second polyol component may include at least one component selected from the group of a polyether polyol having a functionality of not greater than about 4, and a polyester polyol having a functionality of not greater than about 4. The polyurethane foam may have a density of at least about 150 kg/m³. The polyurethane foam may have a compression curve ratio CFD_{70}/CFD_{10} of not greater than about 20, where CFD_{70} is equal to the compression force deflection (CFD) of the polyurethane foam measured at a 70% compression ratio and CFD_{10} is equal to the compression force deflection (CFD) of the polyurethane foam measured at a 10% compression ratio.

According to yet another aspect, a method of forming a polyurethane foam may include providing a raw material mixture and forming the raw material mixture into a polyurethane foam. The raw material mixture may include a raw first polyol component and a raw second polyol component. The raw first polyol component may include a polyether polyol having a functionality of at least about 5. The raw second polyol component may include at least one component selected from the group of a polyether polyol having a functionality of not greater than about 4, and a polyester polyol having a functionality of not greater than about 4. The polyurethane foam may have a density of at least about 150 kg/m³. The polyurethane foam may have a HBF rating based on a UL94 flame retardancy test performed at a polyurethane foam thickness of 1.0 mm.

BRIEF DESCRIPTION OF THE DRAWINGS

Embodiments are illustrated by way of example and are not limited to the accompanying FIGURES.

FIG. 1 includes a diagram showing a polyurethane foam forming method **100** according to embodiments described herein.

Skilled artisans appreciate that elements in the figures are illustrated for simplicity and clarity and have not necessarily been drawn to scale.

DETAILED DESCRIPTION

The following discussion will focus on specific implementations and embodiments of the teachings. The detailed description is provided to assist in describing certain embodiments and should not be interpreted as a limitation on the scope or applicability of the disclosure or teachings. It will be appreciated that other embodiments can be used based on the disclosure and teachings as provided herein.

The terms "comprises," "comprising," "includes," "including," "has," "having" or any other variation thereof, are intended to cover a non-exclusive inclusion. For example, a method, article, or apparatus that comprises a list of features is not necessarily limited only to those features but may include other features not expressly listed or inherent to such method, article, or apparatus. Further,

unless expressly stated to the contrary, “or” refers to an inclusive-or and not to an exclusive-or. For example, a condition A or B is satisfied by any one of the following: A is true (or present) and B is false (or not present), A is false (or not present) and B is true (or present), and both A and B are true (or present).

Also, the use of “a” or “an” is employed to describe elements and components described herein. This is done merely for convenience and to give a general sense of the scope of the invention. This description should be read to include one, at least one, or the singular as also including the plural, or vice versa, unless it is clear that it is meant otherwise. For example, when a single item is described herein, more than one item may be used in place of a single item. Similarly, where more than one item is described herein, a single item may be substituted for that more than one item.

Embodiments described herein are generally directed to a polyurethane foam and methods of forming the same. More particularly, embodiments described herein are directed to a polyurethane foam having superior compression performance and flame retardancy, and methods of forming the same.

For purposes of illustration, FIG. 1 includes a diagram showing a polyurethane foam forming method **100** according to particular embodiments described herein. The polyurethane forming method **100** may include a first step **110** of providing a raw material mixture and a second step **120** of forming the raw material mixture into a polyurethane foam.

Referring to the first step **110**, according to certain embodiments, the raw material mixture may include a raw first polyol component, and a raw second polyol component.

According to certain embodiments, the raw material mixture may include a particular content of raw first polyol component. For example, the raw material mixture may include a content of the raw first polyol component of at least about 2 wt. % for a total weight of the raw material mixture, such as, at least about 3 wt. % or at least about 4 wt. % or even at least about 5 wt. %. According to yet other embodiments, the raw material mixture may include a content of the raw first polyol component of not greater than about 10 wt. % for a total weight of the raw material mixture, such as, not greater than about 9 wt. % or not greater than about 8 wt. % or even not greater than about 7 wt. %. It will be appreciated that the content of the raw first polyol component in the raw material mixture may be within a range between any of the minimum and maximum values noted above. It will be further appreciated that the content of the raw first polyol component in the raw material mixture may be any value between any of the minimum and maximum values noted above.

According to yet other embodiments, the raw first polyol component may have a particular OH number. For example, the raw first polyol component may have an OH number of at least about 400 KOH mg/g, such as, at least about 405 KOH mg/g or at least about 410 KOH mg/g or at least about 415 KOH mg/g or at least about 420 KOH mg/g or even at least about 425 KOH mg/g. According to still other embodiments, the raw first polyol component may have an OH number of not greater than about 450 KOH mg/g, such as, not greater than about 445 KOH mg/g or not greater than about 440 KOH mg/g or not greater than about 435 KOH mg/g or even not greater than about 430 KOH mg/g. It will be appreciated that the OH number of the raw first polyol component may be within a range between any of the minimum and maximum values noted above. It will be further appreciated that the OH number of the raw first

polyol component may be any value between any of the minimum and maximum values noted above.

According to still other embodiments, the raw first polyol component may include polyether polyols, polyester polyols, polymer polyols, bio-based polyols or combinations thereof.

According to yet other embodiments, the raw first polyol component may have a particular functionality. For example, the raw phosphorous polyol component may have a functionality of at least 5, such as, at least 6 or at least 7 or even at least 8.

According to other embodiments, the raw first polyol component may have a particular molecular mass. For example, the raw first polyol component may have a molecular mass of at least about 680 g/mol, such as, at least about 682 g/mol or at least about 684 g/mol or at least about 686 g/mol or at least about 688 g/mol or at least about 690 g/mol or at least about 692 g/mol or at least about 694 g/mol or at least about 696 g/mol or at least about 698 g/mol or even at least about 700. According to still other embodiments, the raw first polyol component may have a molecular mass of not greater than about 850 g/mol, such as, not greater than about 848 g/mol or not greater than about 846 g/mol or not greater than about 844 g/mol or not greater than about 842 g/mol or not greater than about 840 g/mol or not greater than about 838 g/mol or not greater than about 836 g/mol or not greater than about 834 g/mol or not greater than about 832 or even not greater than about 830 g/mol. It will be appreciated that the molecular mass of the raw first polyol component may be within a range between any of the minimum and maximum values noted above. It will be further appreciated that the molecular mass of the raw first polyol component may be any value between any of the minimum and maximum values noted above.

According to certain embodiments, the raw material mixture may include a particular content of raw second polyol component. For example, the raw material mixture may include a content of the raw second polyol component of at least about 5 wt. % for a total weight of the raw material mixture, such as, at least about 6 wt. % or at least about 7 wt. % or at least about 8 wt. % or at least about 9 wt. % or even at least about 10 wt. %. According to yet other embodiments, the raw material mixture may include a content of the raw second polyol component of not greater than about 15 wt. % for a total weight of the raw material mixture, such as, not greater than about 14 wt. % or not greater than about 13 wt. % or not greater than about 12 wt. % or even not greater than about 11 wt. %. It will be appreciated that the content of the raw second polyol component in the raw material mixture may be within a range between any of the minimum and maximum values noted above. It will be further appreciated that the content of the raw second polyol component in the raw material mixture may be any value between any of the minimum and maximum values noted above.

According to yet other embodiments, the raw second polyol component may have a particular OH number. For example, the raw second polyol component may have an OH number of at least about 250.0 KOH mg/g, such as, at least about 260 KOH mg/g or at least about 270 KOH mg/g or at least about 280 KOH mg/g or even at least about 290 KOH mg/g. According to still other embodiments, the raw second polyol component may have an OH number of not greater than about 350.0 KOH mg/g, such as, not greater than about 340 KOH mg/g or not greater than about 330 KOH mg/g or not greater than about 320 KOH mg/g or even not greater than about 310 KOH mg/g. It will be appreciated that the OH

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number of the raw second polyol component may be within a range between any of the minimum and maximum values noted above. It will be further appreciated that the OH number of the raw second polyol component may be any value between any of the minimum and maximum values noted above.

According to still other embodiments, the raw second polyol component may have a particular functionality. For example, the raw second polyol component may have a functionality of not greater than about 4, such as, not greater than about 3 or not greater than about 2 or even not greater than about 1.

According to still other embodiments, the raw second polyol component may include polyether polyol having a particular functionality. For example, the polyether polyol of the second polyol component may have a functionality of not greater than about 4, such as, not greater than about 3 or not greater than about 2 or even not greater than about 1.

According to still other embodiments, the raw second polyol component may include polyester polyol having a particular functionality. For example, the polyester polyol of the second polyol component may have a functionality of not greater than about 4, such as, not greater than about 3 or not greater than about 2 or even not greater than about 1.

According to other embodiments, the raw second polyol component may have a particular molecular mass. For example, the raw second polyol component may have a molecular mass of at least about 500 g/mol, such as, at least about 510 g/mol or at least about 520 g/mol or at least about 530 g/mol or at least about 540 g/mol or at least about 550 g/mol or at least about 560 g/mol or even at least about 570 g/mol. According to still other embodiments, the raw second polyol component may have a molecular mass of not greater than about 650 g/mol, such as, not greater than about 640 g/mol or not greater than about 630 g/mol or not greater than about 620 g/mol or not greater than about 610 g/mol or not greater than about 600 g/mol or not greater than about 590 g/mol or even not greater than about 580 g/mol. It will be appreciated that the molecular mass of the raw second polyol component may be within a range between any of the minimum and maximum values noted above. It will be further appreciated that the molecular mass of the raw second polyol component may be any value between any of the minimum and maximum values noted above.

According to still other embodiments, the raw material mixture may further include a raw third polyol component.

According to certain embodiments, the raw material mixture may include a particular content of raw third polyol component. For example, the raw material mixture may include a content of the raw third polyol component of at least about 5 wt. % for a total weight of the raw material mixture, such as, at least about 6 wt. % or at least about 7 wt. % or at least about 8 wt. % or at least about 9 wt. % or at least about 10 wt. % or at least about 11 wt. % or at least about 12 wt. % or at least about 13 wt. % or at least about 14 wt. % or even at least about 15 wt. %. According to yet other embodiments, the raw material mixture may include a content of the raw third polyol component of not greater than about 25 wt. % for a total weight of the raw material mixture, such as, not greater than about 24 wt. % or not greater than about 23 wt. % or not greater than about 22 wt. % or not greater than about 21 wt. % or not greater than about 20 wt. % or not greater than about 19 wt. % or not greater than about 18 wt. % or not greater than about 17 wt. % or even not greater than about 16 wt. %. It will be appreciated that the content of the raw third polyol component in the raw material mixture may be within a range between any of the

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minimum and maximum values noted above. It will be further appreciated that the content of the raw third polyol component in the raw material mixture may be any value between any of the minimum and maximum values noted above.

According to yet other embodiments, the raw third polyol component may have a particular OH number. For example, the raw third polyol component may have an OH number of at least about 10 KOH mg/g, such as, at least about 12 KOH mg/g or at least about 14 KOH mg/g or at least about 16 KOH mg/g or even at least about 18 KOH mg/g. According to still other embodiments, the raw third polyol component may have an OH number of not greater than about 30 KOH mg/g, such as, not greater than about 28 KOH mg/g or not greater than about 26 KOH mg/g or not greater than about 24 KOH mg/g. It will be appreciated that the OH number of the raw third polyol component may be within a range between any of the minimum and maximum values noted above. It will be further appreciated that the OH number of the raw third polyol component may be any value between any of the minimum and maximum values noted above.

According to yet other embodiments, the raw third polyol component may have a particular functionality. For example, the raw phosphorous polyol component may have a functionality of not greater than 5, such as, not greater than 4 or not greater than 3 or not greater than 2 or even 1.

According to other embodiments, the raw third polyol component may have a particular molecular mass. For example, the raw third polyol component may have a molecular mass of at least about 7000 g/mol, such as, at least about 7250 g/mol or at least about 7500 g/mol or at least about 7750 g/mol or at least about 8000 g/mol or even at least about 8250 g/mol. According to still other embodiments, the raw third polyol component may have a molecular mass of not greater than about 10000 g/mol, such as, not greater than about 9750 g/mol or not greater than about 9500 g/mol or not greater than about 9250 g/mol or not greater than about 9000 g/mol or not greater than about 8750 g/mol or even not greater than about 8500 g/mol. It will be appreciated that the molecular mass of the raw third polyol component may be within a range between any of the minimum and maximum values noted above. It will be further appreciated that the molecular mass of the raw third polyol component may be any value between any of the minimum and maximum values noted above.

According to still other embodiments, the raw material mixture may further include a raw fourth polyol component.

According to certain embodiments, the raw material mixture may include a particular content of raw fourth polyol component. For example, the raw material mixture may include a content of the raw fourth polyol component of at least about 15 wt. % for a total weight of the raw material mixture, such as, at least about 16 wt. % or at least about 17 wt. % or at least about 18 wt. % or at least about 19 wt. % or at least about 20 wt. % or at least about 21 wt. % or at least about 22 wt. % or at least about 23 wt. % or at least about 24 wt. % or even at least about 25 wt. %. According to yet other embodiments, the raw material mixture may include a content of the raw fourth polyol component of not greater than about 45 wt. % for a total weight of the raw material mixture, such as, not greater than about 44 wt. % or not greater than about 43 wt. % or not greater than about 42 wt. % or not greater than about 41 wt. % or not greater than about 40 wt. % or not greater than about 39 wt. % or not greater than about 38 wt. % or not greater than about 37 wt. % or even not greater than about 33 wt. %. It will be appreciated that the content of the raw fourth polyol com-

ponent in the raw material mixture may be within a range between any of the minimum and maximum values noted above. It will be further appreciated that the content of the raw fourth polyol component in the raw material mixture may be any value between any of the minimum and maximum values noted above.

According to yet other embodiments, the raw fourth polyol component may have a particular OH number. For example, the raw fourth polyol component may have an OH number of at least about 52 KOH mg/g, such as, at least about 52.5 KOH mg/g or at least about 53.0 KOH mg/g or at least about 53.5 KOH mg/g or even at least about 54.0 KOH mg/g. According to still other embodiments, the raw fourth polyol component may have an OH number of not greater than about 56.0 KOH mg/g, such as, not greater than about 55.5 KOH mg/g or not greater than about 55.0 KOH mg/g or not greater than about 54.5 KOH mg/g. It will be appreciated that the OH number of the raw fourth polyol component may be within a range between any of the minimum and maximum values noted above. It will be further appreciated that the OH number of the raw fourth polyol component may be any value between any of the minimum and maximum values noted above.

According to yet other embodiments, the raw fourth polyol component may have a particular functionality. For example, the raw phosphorous polyol component may have a functionality of not greater than 5, such as, not greater than 4 or not greater than 3 or not greater than 2 or even 1.

According to other embodiments, the raw fourth polyol component may have a particular molecular mass. For example, the raw fourth polyol component may have a molecular mass of at least about 2800 g/mol, such as, at least about 3000 g/mol. According to still other embodiments, the raw fourth polyol component may have a molecular mass of not greater than about 3600 g/mol, such as, not greater than about 3400 g/mol. It will be appreciated that the molecular mass of the raw fourth polyol component may be within a range between any of the minimum and maximum values noted above. It will be further appreciated that the molecular mass of the raw fourth polyol component may be any value between any of the minimum and maximum values noted above.

According to still other embodiments, the raw material mixture may further include a raw catalyst component.

According to still other embodiments, the raw catalyst component may include metal catalysts containing metal component such as tin, copper, lead, zinc, cobalt, or nickel, and amine catalysts such as tertiary amine or quaternary ammonium salt.

According to certain embodiments, the raw material mixture may include a particular content of raw catalyst component. For example, the raw material mixture may include a content of the raw catalyst component of at least about 0.1 wt. % for a total weight of the raw material mixture, such as, at least about 0.25 wt. % or at least about 0.5 wt. % or at least about 0.75 wt. % or at least about 1.0 wt. % or at least about 1.25 wt. % or even at least about 1.5 wt. %. According to yet other embodiments, the raw material mixture may include a content of the raw catalyst component of not greater than about 5 wt. % for a total weight of the raw material mixture, such as, not greater than about 4.75 wt. % or not greater than about 4.5 wt. % or not greater than about 4.25 wt. % or not greater than about 4.0 wt. % or not greater than about 3.75 wt. % or not greater than about 3.5 wt. % or not greater than about 3.25 wt. % or not greater than about 3.0 wt. % or not greater than about 2.75 wt. % or not greater than about 2.5 wt. % or not greater than about 2.25 wt. % or even not

greater than about 2.0 wt. %. It will be appreciated that the content of the raw catalyst component in the raw material mixture may be within a range between any of the minimum and maximum values noted above. It will be further appreciated that the content of the raw catalyst component in the raw material mixture may be any value between any of the minimum and maximum values noted above.

According to still other embodiments, the raw material mixture may further include a raw pigment component.

According to still other embodiments, the raw pigment component may include carbon dispersions in polyols.

According to certain embodiments, the raw material mixture may include a particular content of raw pigment component. For example, the raw material mixture may include a content of the raw pigment component of at least about 0.1 wt. % for a total weight of the raw material mixture, such as, at least about 0.25 wt. % or at least about 0.5 wt. % or at least about 0.75 wt. % or at least about 1.0 wt. % or at least about 1.25 wt. % or even at least about 1.5 wt. %. According to yet other embodiments, the raw material mixture may include a content of the raw pigment component of not greater than about 5 wt. % for a total weight of the raw material mixture, such as, not greater than about 4.75 wt. % or not greater than about 4.5 wt. % or not greater than about 4.25 wt. % or not greater than about 4.0 wt. % or not greater than about 3.75 wt. % or not greater than about 3.5 wt. % or not greater than about 3.25 wt. % or not greater than about 3.0 wt. % or not greater than about 2.75 wt. % or not greater than about 2.5 wt. % or not greater than about 2.25 wt. % or even not greater than about 2.0 wt. %. It will be appreciated that the content of the raw pigment component in the raw material mixture may be within a range between any of the minimum and maximum values noted above. It will be further appreciated that the content of the raw pigment component in the raw material mixture may be any value between any of the minimum and maximum values noted above.

According to still other embodiments, the raw material mixture may further include a raw chain extender component.

According to still other embodiments, the raw chain extender component may include compounds with at least two isocyanate reactive groups such as diethylene glycol, triethylene glycol, dipropylene glycol, or tri propylene glycol.

According to certain embodiments, the raw material mixture may include a particular content of raw chain extender component. For example, the raw material mixture may include a content of the raw chain extender component of at least about 0.1 wt. % for a total weight of the raw material mixture, such as, at least about 0.25 wt. % or at least about 0.5 wt. % or at least about 0.75 wt. % or at least about 1.0 wt. % or at least about 1.25 wt. % or even at least about 1.5 wt. %. According to yet other embodiments, the raw material mixture may include a content of the raw chain extender component of not greater than about 5 wt. % for a total weight of the raw material mixture, such as, not greater than about 4.75 wt. % or not greater than about 4.5 wt. % or not greater than about 4.25 wt. % or not greater than about 4.0 wt. % or not greater than about 3.75 wt. % or not greater than about 3.5 wt. % or not greater than about 3.25 wt. % or not greater than about 3.0 wt. % or not greater than about 2.75 wt. % or not greater than about 2.5 wt. % or not greater than about 2.25 wt. % or even not greater than about 2.0 wt. %. It will be appreciated that the content of the raw chain extender component in the raw material mixture may be within a range between any of the minimum and maximum values noted above. It will be further appreciated that the

content of the raw chain extender component in the raw material mixture may be any value between any of the minimum and maximum values noted above.

According to still other embodiments, the raw material mixture may further include a raw thixotropic agent component.

According to still other embodiments, the raw thixotropic agent component may include aerosol, bentonite, polyuria compounds or combinations thereof.

According to certain embodiments, the raw material mixture may include a particular content of raw thixotropic agent component. For example, the raw material mixture may include a content of the raw thixotropic agent component of at least about 0.1 wt. % for a total weight of the raw material mixture, such as, at least about 0.25 wt. % or at least about 0.5 wt. % or at least about 0.75 wt. % or at least about 1.0 wt. % or at least about 1.25 wt. % or even at least about 1.5 wt. %. According to yet other embodiments, the raw material mixture may include a content of the raw thixotropic agent component of not greater than about 4 wt. % for a total weight of the raw material mixture, such as, not greater than about 3.75 wt. % or not greater than about 3.5 wt. % or not greater than about 3.25 wt. % or not greater than about 3.0 wt. % or not greater than about 2.75 wt. % or not greater than about 2.5 wt. % or not greater than about 2.25 wt. % or even not greater than about 2.0 wt. %. It will be appreciated that the content of the raw thixotropic agent component in the raw material mixture may be within a range between any of the minimum and maximum values noted above. It will be further appreciated that the content of the raw thixotropic agent component in the raw material mixture may be any value between any of the minimum and maximum values noted above.

According to still other embodiments, the raw material mixture may further include a raw isocyanate component.

According to still other embodiments, the raw isocyanate component may include monomeric methylenediphenyl diisocyanate (MDI), modified MDI, polymeric MDI and combinations thereof.

According to certain embodiments, the raw material mixture may include a particular content of raw isocyanate component. For example, the raw material mixture may include a content of the raw isocyanate component of at least about 8.0 wt. % for a total weight of the raw material mixture, such as, at least about 9 wt. % or at least about 10 wt. % or at least about 11 wt. % or at least about 12 wt. % or at least about 13 wt. % or at least about 14 wt. % or even at least about 15 wt. %. According to yet other embodiments, the raw material mixture may include a content of the raw isocyanate component of not greater than about 25 wt. % for a total weight of the raw material mixture, such as, not greater than about 24 wt. % or not greater than about 23 wt. % or not greater than about 22 wt. % or not greater than about 21 wt. % or even not greater than about 20 wt. %. It will be appreciated that the content of the raw isocyanate component in the raw material mixture may be within a range between any of the minimum and maximum values noted above. It will be further appreciated that the content of the raw isocyanate component in the raw material mixture may be any value between any of the minimum and maximum values noted above.

According to still other embodiments, the raw material mixture may further include a raw surfactant component.

According to certain embodiments, the raw material mixture may include a particular content of the raw surfactant component. For example, the raw material mixture may include a content of the raw surfactant component of at least

about 1 wt. % for a total weight of the raw material mixture, such as, at least about 1.5 wt. % or at least about 2.0 wt. % or at least about 2.5 wt. % or at least about 3.0 wt. % or at least about 3.5 wt. % or even at least about 4.0 wt. %.

According to yet other embodiments, the raw material mixture may include a content of the raw surfactant component of not greater than about 15.0 wt. % for a total weight of the raw material mixture, such as, not greater than about 14.0 wt. % or not greater than about 13.0 wt. % or not greater than about 12.0 wt. % or not greater than about 11.0 wt. % or not greater than about 10.0 wt. % or not greater than about 9.0 wt. % or not greater than about 8.0 wt. % or even not greater than about 7.0 wt. %. It will be appreciated that the content of the raw surfactant component in the raw material mixture may be within a range between any of the minimum and maximum values noted above. It will be further appreciated that the content of raw surfactant component in the raw material mixture may be any value between any of the minimum and maximum values noted above.

According to yet other embodiments, forming the raw material mixture into a polyurethane foam may include foaming the raw material mixture to form a foamed material mixture. According to still other embodiments, forming the raw material mixture into a polyurethane foam may further include curing the foamed material mixture to form the polyurethane foam.

Referring now to the polyurethane foam formed according to embodiments described herein, the polyurethane foam may include a first polyol component, a second polyol component.

According to other embodiments, the polyurethane foam may have a particular compression curve ratio CFD_{70}/CFD_{10} , where CFD_{70} is equal to the compression force deflection (CFD) of the polyurethane foam measured according to ASTM #D3574 at a 70% compression ratio and CFD_{10} is equal to the compression force deflection (CFD) of the polyurethane foam measured according to ASTM #D3574 at a 10% compression ratio. For example, the polyurethane foam may have a compression curve ratio CFD_{70}/CFD_{10} of not greater than about 20, such as, not greater than about 19.5 or not greater than about 19.0 or not greater than about 18.5 or not greater than about 18.0 or not greater than about 17.5 or not greater than about 17.0 or not greater than about 16.5 or not greater than about 16.0 or not greater than about 15.5 or even not greater than about 15.

According to still other embodiments, the polyurethane foam may have a compression curve ratio CFD_{70}/CFD_{10} of at least about 8, such as, at least about 9 or at least about 10 or even at least about 11. It will be appreciated that the compression curve ratio CFD_{70}/CFD_{10} of the polyurethane foam may be within a range between any of the minimum and maximum values noted above. It will be further appreciated that the CFD_{70}/CFD_{10} of the polyurethane foam may be any value between any of the minimum and maximum values noted above.

According to particular embodiments, the polyurethane foam may have a particular compression force deflection (CFD_{10}) as measured according to ASTM #D3574 at a 10% compression ratio. For example, the polyurethane foam may have a CFD_{10} of at least about 40 KPa as measured at 10% compression ratio, such as, at least about 45 KPa or at least about 50 KPa or at least about 55 KPa or at least about 60 KPa or at least about 65 KPa or even at least about 70 KPa. According to still other embodiments, the polyurethane foam may have a CFD_{10} of not greater than about 250 KPa, such as, not greater than about 240 KPa or not greater than about 230 KPa or not greater than about 220 KPa or not

greater than about 210 KPa or not greater than about 200 KPa or not greater than about 190 KPa or not greater than about 180 KPa or not greater than about 170 KPa or not greater than about 160 KPa or not greater than about 150 KPa or not greater than about 140 KPa or not greater than about 130 KPa or not greater than about 120 KPa or not greater than about 115 KPa or not greater than about 110 KPa or not greater than about 105 KPa or not greater than about 100 KPa or not greater than about 95 KPa or not greater than about 90 KPa or even not greater than about 85 KPa. It will be appreciated that the CFD_{10} of the polyurethane foam may be within a range between any of the minimum and maximum values noted above. It will be further appreciated that the CFD_{10} of the polyurethane foam may be any value between any of the minimum and maximum values noted above.

According to yet other embodiments, the polyurethane foam may have a particular compression force deflection (CFD_{70}) as measured according to ASTM #D3574 at a 70% compression ratio. For example, the polyurethane foam may have a CFD_{70} of at least about 200 KPa as measured at 70% compression ratio, such as, at least about 250 KPa or at least about 300 KPa or at least about 350 KPa or at least about 400 KPa or at least about 450 KPa or at least about 500 KPa or at least about 550 KPa or at least about 600 KPa or at least about 650 KPa or at least about 700 KPa or at least about 750 KPa or at least about 800 KPa or even at least about 850 KPa. According to still other embodiments, the polyurethane foam may have a CFD_{70} of not greater than about 2500 KPa, such as, not greater than about 2400 KPa or not greater than about 2300 KPa or not greater than about 2200 KPa or not greater than about 2100 KPa or not greater than about 2000 KPa or not greater than about 1900 KPa or not greater than about 1800 KPa or not greater than about 1700 KPa or not greater than about 1600 KPa or not greater than about 1500 KPa or not greater than about 1400 KPa or not greater than about 1300 KPa or not greater than about 1200 KPa or even not greater than about 1100 KPa. It will be appreciated that the CFD_{70} of the polyurethane foam may be within a range between any of the minimum and maximum values noted above. It will be further appreciated that the CFD_{70} of the polyurethane foam may be any value between any of the minimum and maximum values noted above.

According to particular embodiments, the polyurethane foam formed according to embodiments described herein may have a HBF rating based on a UL94 flame retardancy test performed at a polyurethane foam thickness of 3.5 mm.

According to other embodiments, the polyurethane foam formed according to embodiments described herein may have a HBF rating based on a UL94 flame retardancy test performed at a polyurethane foam thickness of 3.0 mm.

According to other embodiments, the polyurethane foam formed according to embodiments described herein may have a HBF rating based on a UL94 flame retardancy test performed at a polyurethane foam thickness of 2.5 mm.

According to other embodiments, the polyurethane foam formed according to embodiments described herein may have a HBF rating based on a UL94 flame retardancy test performed at a polyurethane foam thickness of 1.0 mm.

According to still other embodiments, the polyurethane foam may have a particular density as measured according to ASTM #D3574. For example, the polyurethane foam may have a density of at least about 150 kg/m^3 , such as, at least about 160 kg/m^3 or at least about 170 kg/m^3 or at least about 180 kg/m^3 or at least about 190 kg/m^3 or at least about 200 kg/m^3 or at least about 210 kg/m^3 or at least about 220 kg/m^3 or at least about 230 kg/m^3 or at least about 240 kg/m^3 or at

least about 250 kg/m^3 or at least about 260 kg/m^3 or at least about 270 kg/m^3 or at least about 280 kg/m^3 or even at least about 290 kg/m^3 . According to still other embodiments, the polyurethane foam may have a density of not greater than about 350 kg/m^3 , such as, not greater than about 345 kg/m^3 or not greater than about 340 kg/m^3 or not greater than about 335 kg/m^3 or even not greater than about 330 kg/m^3 . It will be appreciated that the density of the polyurethane foam may be within a range between any of the minimum and maximum values noted above. It will be further appreciated that the density of the polyurethane foam may be any value between any of the minimum and maximum values noted above.

According to certain embodiments, the polyurethane foam may include a particular content of the first polyol component. For example, the polyurethane foam may include a content of the first polyol component of at least about 2 wt. % for a total weight of the polyurethane foam, such as, at least about 3 wt. % or at least about 4 wt. % or even at least about 5 wt. %. According to yet other embodiments, the polyurethane foam may include a content of the first polyol component of not greater than about 10 wt. % for a total weight of the polyurethane foam, such as, not greater than about 9 wt. % or not greater than about 8 wt. % or even not greater than about 7 wt. %. It will be appreciated that the content of the first polyol component in the polyurethane foam may be within a range between any of the minimum and maximum values noted above. It will be further appreciated that the content of the first polyol component in the polyurethane foam may be any value between any of the minimum and maximum values noted above.

According to yet other embodiments, the first polyol component may have a particular OH number. For example, the first polyol component may have an OH number of at least about 400 KOH mg/g, such as, at least about 405 KOH mg/g or at least about 410 KOH mg/g or at least about 415 KOH mg/g or at least about 420 KOH mg/g or even at least about 425 KOH mg/g. According to still other embodiments, the first polyol component may have an OH number of not greater than about 450 KOH mg/g, such as, not greater than about 445 KOH mg/g or not greater than about 440 KOH mg/g or not greater than about 435 KOH mg/g or even not greater than about 430 KOH mg/g. It will be appreciated that the OH number of the first polyol component may be within a range between any of the minimum and maximum values noted above. It will be further appreciated that the OH number of the first polyol component may be any value between any of the minimum and maximum values noted above.

According to still other embodiments, the first polyol component may include polyether polyols, polyester polyols, polymer polyols, bio-based polyols or combinations thereof.

According to yet other embodiments, the first polyol component may have a particular functionality. For example, the phosphorous polyol component may have a functionality of at least 5, such as, at least 6 or at least 7 or even at least 8.

According to other embodiments, the first polyol component may have a particular molecular mass. For example, the first polyol component may have a molecular mass of at least about 680 g/mol, such as, at least about 682 g/mol or at least about 684 g/mol or at least about 686 g/mol or at least about 688 g/mol or at least about 690 g/mol or at least about 692 g/mol or at least about 694 g/mol or at least about 696 g/mol or at least about 698 g/mol or even at least about 700 g/mol. According to still other embodiments, the first polyol com-

ponent may have a molecular mass of not greater than about 850 g/mol, such as, not greater than about 848 g/mol or not greater than about 846 g/mol or not greater than about 844 g/mol or not greater than about 842 g/mol or not greater than about 840 g/mol or not greater than about 838 g/mol or not greater than about 836 g/mol or not greater than about 834 g/mol or not greater than about 832 g/mol or even not greater than about 830 g/mol. It will be appreciated that the molecular mass of the first polyol component may be within a range between any of the minimum and maximum values noted above. It will be further appreciated that the molecular mass of the first polyol component may be any value between any of the minimum and maximum values noted above.

According to certain embodiments, the polyurethane foam may include a particular content of a second polyol component. For example, the polyurethane foam may include a content of the second polyol component of at least about 5 wt. % for a total weight of the polyurethane foam, such as, at least about 6 wt. % or at least about 7 wt. % or at least about 8 wt. % or at least about 9 wt. % or even at least about 10 wt. %. According to yet other embodiments, the polyurethane foam may include a content of the second polyol component of not greater than about 15 wt. % for a total weight of the polyurethane foam, such as, not greater than about 14 wt. % or not greater than about 13 wt. % or not greater than about 12 wt. % or even not greater than about 11 wt. %. It will be appreciated that the content of the second polyol component in the polyurethane foam may be any value between any of the minimum and maximum values noted above.

According to yet other embodiments, the second polyol component may have a particular OH number. For example, the second polyol component may have an OH number of at least about 250.0 KOH mg/g, such as, at least about 260 KOH mg/g or at least about 270 KOH mg/g or at least about 280 KOH mg/g or even at least about 290 KOH mg/g. According to still other embodiments, the second polyol component may have an OH number of not greater than about 350 KOH mg/g, such as, not greater than about 340 KOH mg/g or not greater than about 330 KOH mg/g or not greater than about 320 KOH mg/g or even not greater than about 310 KOH mg/g. It will be appreciated that the OH number of the second polyol component may be within a range between any of the minimum and maximum values noted above. It will be further appreciated that the OH number of the second polyol component may be any value between any of the minimum and maximum values noted above.

According to still other embodiments, the second polyol component may have a particular functionality. For example, the second polyol component may have a functionality of not greater than about 4, such as, not greater than about 3 or not greater than about 2 or even not greater than about 1.

According to still other embodiments, the second polyol component may include polyether polyol having a particular functionality. For example, the polyether polyol of the second polyol component may have a functionality of not greater than about 4, such as, not greater than about 3 or not greater than about 2 or even not greater than about 1.

According to still other embodiments, the second polyol component may include polyester polyol having a particular functionality. For example, the polyester polyol of the second polyol component may have a functionality of not

greater than about 4, such as, not greater than about 3 or not greater than about 2 or even not greater than about 1.

According to other embodiments, the second polyol component may have a particular molecular mass. For example, the second polyol component may have a molecular mass of at least about 500 g/mol, such as, at least about 510 g/mol or at least about 520 g/mol or at least about 530 g/mol or at least about 540 g/mol or at least about 550 g/mol or at least about 560 g/mol or even at least about 570 g/mol. According to still other embodiments, the second polyol component may have a molecular mass of not greater than about 650 g/mol, such as, not greater than about 640 g/mol or not greater than about 630 g/mol or not greater than about 620 g/mol or not greater than about 610 g/mol or not greater than about 600 g/mol or not greater than about 590 g/mol or even not greater than about 580 g/mol. It will be appreciated that the molecular mass of the second polyol component may be within a range between any of the minimum and maximum values noted above. It will be further appreciated that the molecular mass of the second polyol component may be any value between any of the minimum and maximum values noted above.

According to still other embodiments, the polyurethane foam may further include a third polyol component.

According to certain embodiments, the polyurethane foam may include a particular content of third polyol component. For example, the polyurethane foam may include a content of the third polyol component of at least about 5 wt. % for a total weight of the polyurethane foam, such as, at least about 6 wt. % or at least about 7 wt. % or at least about 8 wt. % or at least about 9 wt. % or at least about 10 wt. % or at least about 11 wt. % or at least about 12 wt. % or at least about 13 wt. % or at least about 14 wt. % or even at least about 15 wt. %. According to yet other embodiments, the polyurethane foam may include a content of the third polyol component of not greater than about 25 wt. % for a total weight of the polyurethane foam, such as, not greater than about 24 wt. % or not greater than about 23 wt. % or not greater than about 22 wt. % or not greater than about 21 wt. % or not greater than about 20 wt. % or not greater than about 19 wt. % or not greater than about 18 wt. % or not greater than about 17 wt. % or even not greater than about 16 wt. %. It will be appreciated that the content of the third polyol component in the polyurethane foam may be within a range between any of the minimum and maximum values noted above. It will be further appreciated that the content of the third polyol component in the polyurethane foam may be any value between any of the minimum and maximum values noted above.

According to yet other embodiments, the third polyol component may have a particular OH number. For example, the third polyol component may have an OH number of at least about 10 KOH mg/g, such as, at least about 12 KOH mg/g or at least about 14 KOH mg/g or at least about 16 KOH mg/g or even at least about 18 KOH mg/g. According to still other embodiments, the third polyol component may have an OH number of not greater than about 30 KOH mg/g, such as, not greater than about 28 KOH mg/g or not greater than about 26 KOH mg/g or not greater than about 24 KOH mg/g. It will be appreciated that the OH number of the third polyol component may be within a range between any of the minimum and maximum values noted above. It will be further appreciated that the OH number of the third polyol component may be any value between any of the minimum and maximum values noted above.

According to yet other embodiments, the third polyol component may have a particular functionality. For

example, the phosphorous polyol component may have a functionality of not greater than 5, such as, not greater than 4 or not greater than 3 or not greater than 2 or even 1.

According to other embodiments, the third polyol component may have a particular molecular mass. For example, the third polyol component may have a molecular mass of at least about 7000 g/mol, such as, at least about 7250 g/mol or at least about 7500 g/mol or at least about 7750 g/mol or at least about 8000 g/mol or even at least about 8250 g/mol. According to still other embodiments, the third polyol component may have a molecular mass of not greater than about 10000 g/mol, such as, not greater than about 9750 g/mol or not greater than about 9500 g/mol or not greater than about 9250 g/mol or not greater than about 9000 g/mol or not greater than about 8750 g/mol or even not greater than about 8500 g/mol. It will be appreciated that the molecular mass of the third polyol component may be within a range between any of the minimum and maximum values noted above. It will be further appreciated that the molecular mass of the third polyol component may be any value between any of the minimum and maximum values noted above.

According to still other embodiments, the polyurethane foam may further include a fourth polyol component.

According to certain embodiments, the polyurethane foam may include a particular content of a fourth polyol component. For example, the polyurethane foam may include a content of the fourth polyol component of at least about 15 wt. % for a total weight of the polyurethane foam, such as, at least about 16 wt. % or at least about 17 wt. % or at least about 18 wt. % or at least about 19 wt. % or at least about 20 wt. % or at least about 21 wt. % or at least about 22 wt. % or at least about 23 wt. % or at least about 24 wt. % or even at least about 25 wt. %. According to yet other embodiments, the polyurethane foam may include a content of the fourth polyol component of not greater than about 45 wt. % for a total weight of the polyurethane foam, such as, not greater than about 44 wt. % or not greater than about 43 wt. % or not greater than about 42 wt. % or not greater than about 41 wt. % or not greater than about 40 wt. % or not greater than about 39 wt. % or not greater than about 38 wt. % or not greater than about 37 wt. % or even not greater than about 33 wt. %. It will be appreciated that the content of the fourth polyol component in the polyurethane foam may be within a range between any of the minimum and maximum values noted above. It will be further appreciated that the content of the fourth polyol component in the polyurethane foam may be any value between any of the minimum and maximum values noted above.

According to yet other embodiments, the fourth polyol component may have a particular OH number. For example, the fourth polyol component may have an OH number of at least about 52 KOH mg/g, such as, at least about 52.5 KOH mg/g or at least about 53.0 KOH mg/g or at least about 53.5 KOH mg/g or even at least about 54.0 KOH mg/g. According to still other embodiments, the fourth polyol component may have an OH number of not greater than about 56.0 KOH mg/g, such as, not greater than about 55.5 KOH mg/g or not greater than about 55.0 KOH mg/g or not greater than about 54.5 KOH mg/g. It will be appreciated that the OH number of the fourth polyol component may be within a range between any of the minimum and maximum values noted above. It will be further appreciated that the OH number of the fourth polyol component may be any value between any of the minimum and maximum values noted above.

According to yet other embodiments, the fourth polyol component may have a particular functionality. For example, the phosphorous polyol component may have a

functionality of not greater than 5, such as, not greater than 4 or not greater than 3 or not greater than 2 or even 1.

According to other embodiments, the fourth polyol component may have a particular molecular mass. For example, the fourth polyol component may have a molecular mass of at least about 2800 g/mol, such as, at least about 3000 g/mol. According to still other embodiments, the fourth polyol component may have a molecular mass of not greater than about 3600 g/mol, such as, not greater than about 3400 g/mol. It will be appreciated that the molecular mass of the fourth polyol component may be within a range between any of the minimum and maximum values noted above. It will be further appreciated that the molecular mass of the fourth polyol component may be any value between any of the minimum and maximum values noted above.

According to still other embodiments, the polyurethane foam may further include a catalyst component.

According to still other embodiments, the catalyst component may include metal catalysts containing metal component such as tin, copper, lead, zinc, cobalt, or nickel, and amine catalysts such as tertiary amine or quaternary ammonium salt.

According to certain embodiments, the polyurethane foam may include a particular content of catalyst component. For example, the polyurethane foam may include a content of the catalyst component of at least about 0.1 wt. % for a total weight of the polyurethane foam, such as, at least about 0.25 wt. % or at least about 0.5 wt. % or at least about 0.75 wt. % or at least about 1.0 wt. % or at least about 1.25 wt. % or even at least about 1.5 wt. %. According to yet other embodiments, the polyurethane foam may include a content of the catalyst component of not greater than about 5 wt. % for a total weight of the polyurethane foam, such as, not greater than about 4.75 wt. % or not greater than about 4.5 wt. % or not greater than about 4.25 wt. % or not greater than about 4.0 wt. % or not greater than about 3.75 wt. % or not greater than about 3.5 wt. % or not greater than about 3.25 wt. % or not greater than about 3.0 wt. % or not greater than about 2.75 wt. % or not greater than about 2.5 wt. % or not greater than about 2.25 wt. % or even not greater than about 2.0 wt. %. It will be appreciated that the content of the catalyst component in the polyurethane foam may be within a range between any of the minimum and maximum values noted above. It will be further appreciated that the content of the catalyst component in the polyurethane foam may be any value between any of the minimum and maximum values noted above.

According to still other embodiments, the polyurethane foam may further include a pigment component.

According to still other embodiments, the pigment component may include carbon dispersions in polyols.

According to certain embodiments, the polyurethane foam may include a particular content of pigment component. For example, the polyurethane foam may include a content of the pigment component of at least about 0.1 wt. % for a total weight of the polyurethane foam, such as, at least about 0.25 wt. % or at least about 0.5 wt. % or at least about 0.75 wt. % or at least about 1.0 wt. % or at least about 1.25 wt. % or even at least about 1.5 wt. %. According to yet other embodiments, the polyurethane foam may include a content of the pigment component of not greater than about 5 wt. % for a total weight of the polyurethane foam, such as, not greater than about 4.75 wt. % or not greater than about 4.5 wt. % or not greater than about 4.25 wt. % or not greater than about 4.0 wt. % or not greater than about 3.75 wt. % or not greater than about 3.5 wt. % or not greater than about 3.25 wt. % or not greater than about 3.0 wt. % or not greater

than about 2.75 wt. % or not greater than about 2.5 wt. % or not greater than about 2.25 wt. % or even not greater than about 2.0 wt. %. It will be appreciated that the content of the pigment component in the polyurethane foam may be within a range between any of the minimum and maximum values noted above. It will be further appreciated that the content of the pigment component in the polyurethane foam may be any value between any of the minimum and maximum values noted above.

According to still other embodiments, the polyurethane foam may further include a chain extender component.

According to still other embodiments, the chain extender component may include compounds with at least two isocyanate reactive groups such as diethylene glycol, triethylene glycol, dipropylene glycol, or tri propylene glycol.

According to certain embodiments, the polyurethane foam may include a particular content of chain extender component. For example, the polyurethane foam may include a content of the chain extender component of at least about 0.1 wt. % for a total weight of the polyurethane foam, such as, at least about 0.25 wt. % or at least about 0.5 wt. % or at least about 0.75 wt. % or at least about 1.0 wt. % or at least about 1.25 wt. % or even at least about 1.5 wt. %. According to yet other embodiments, the polyurethane foam may include a content of the chain extender component of not greater than about 5 wt. % for a total weight of the polyurethane foam, such as, not greater than about 4.75 wt. % or not greater than about 4.5 wt. % or not greater than about 4.25 wt. % or not greater than about 4.0 wt. % or not greater than about 3.75 wt. % or not greater than about 3.5 wt. % or not greater than about 3.25 wt. % or not greater than about 3.0 wt. % or not greater than about 2.75 wt. % or not greater than about 2.5 wt. % or not greater than about 2.25 wt. % or even not greater than about 2.0 wt. %. It will be appreciated that the content of the chain extender component in the polyurethane foam may be within a range between any of the minimum and maximum values noted above. It will be further appreciated that the content of the chain extender component in the polyurethane foam may be any value between any of the minimum and maximum values noted above.

According to still other embodiments, the polyurethane foam may further include a thixotropic agent component.

According to still other embodiments, the thixotropic agent component may include aerosol, bentonite, polyuria compounds or combinations thereof.

According to certain embodiments, the polyurethane foam may include a particular content of thixotropic agent component. For example, the polyurethane foam may include a content of the thixotropic agent component of at least about 0.1 wt. % for a total weight of the polyurethane foam, such as, at least about 0.25 wt. % or at least about 0.5 wt. % or at least about 0.75 wt. % or at least about 1.0 wt. % or at least about 1.25 wt. % or even at least about 1.5 wt. %. According to yet other embodiments, the polyurethane foam may include a content of the thixotropic agent component of not greater than about 4 wt. % for a total weight of the polyurethane foam, such as, not greater than about 3.75 wt. % or not greater than about 3.5 wt. % or not greater than about 3.25 wt. % or not greater than about 3.0 wt. % or not greater than about 2.75 wt. % or not greater than about 2.5 wt. % or not greater than about 2.25 wt. % or even not greater than about 2.0 wt. %. It will be appreciated that the content of the thixotropic agent component in the polyurethane foam may be within a range between any of the minimum and maximum values noted above. It will be further appreciated that the content of the thixotropic agent

component in the polyurethane foam may be any value between any of the minimum and maximum values noted above.

According to still other embodiments, the polyurethane foam may further include a isocyanate component.

According to still other embodiments, the isocyanate component may include monomeric methylenediphenyl diisocyanate (MDI), modified MDI, polymeric MDI and combinations thereof.

According to certain embodiments, the polyurethane foam may include a particular content of isocyanate component. For example, the polyurethane foam may include a content of the isocyanate component of at least about 8.0 wt. % for a total weight of the polyurethane foam, such as, at least about 9 wt. % or at least about 10 wt. % or at least about 11 wt. % or at least about 12 wt. % or at least about 13 wt. % or at least about 14 wt. % or even at least about 15 wt. %. According to yet other embodiments, the polyurethane foam may include a content of the isocyanate component of not greater than about 25 wt. % for a total weight of the polyurethane foam, such as, not greater than about 24 wt. % or not greater than about 23 wt. % or not greater than about 22 wt. % or not greater than about 21 wt. % or even not greater than about 20 wt. %. It will be appreciated that the content of the isocyanate component in the polyurethane foam may be within a range between any of the minimum and maximum values noted above. It will be further appreciated that the content of the isocyanate component in the polyurethane foam may be any value between any of the minimum and maximum values noted above.

According to still other embodiments, the polyurethane foam may further include a surfactant component.

According to certain embodiments, the polyurethane foam may include a particular content of the surfactant component. For example, the polyurethane foam may include a content of the surfactant component of at least about 1 wt. % for a total weight of the polyurethane foam, such as, at least about 1.5 wt. % or at least about 2.0 wt. % or at least about 2.5 wt. % or at least about 3.0 wt. % or at least about 3.5 wt. % or even at least about 4.0 wt. %. According to yet other embodiments, the polyurethane foam may include a content of the surfactant component of not greater than about 15.0 wt. % for a total weight of the polyurethane foam, such as, not greater than about 14.0 wt. % or not greater than about 13.0 wt. % or not greater than about 12.0 wt. % or not greater than about 11.0 wt. % or not greater than about 10.0 wt. % or not greater than about 9.0 wt. % or not greater than about 8.0 wt. % or even not greater than about 7.0 wt. %. It will be appreciated that the content of the surfactant component in the polyurethane foam may be within a range between any of the minimum and maximum values noted above. It will be further appreciated that the content of surfactant component in the polyurethane foam may be any value between any of the minimum and maximum values noted above.

According to yet other embodiments, the polyurethane foam may have a particular thickness. For example, the polyurethane foam may have a thickness of at least about 0.5 mm, such as, at least about 0.55 mm or at least about 0.6 mm or at least about 0.65 mm or at least about 0.7 mm or even at least about 0.75 mm. According to still other embodiments, the polyurethane foam may have a thickness of not greater than about 15 mm, such as, not greater than about 14.5 mm or not greater than about 14.0 mm or not greater than about 13.5 mm or not greater than about 13.0 mm or not greater than about 12.5 mm or not greater than about 12.0 mm or not greater than about 11.5 mm or not greater than

about 11.0 mm or not greater than about 10.5 mm or not greater than about 10.0 mm or not greater than about 9.5 mm or not greater than about 9.0 mm or not greater than about 8.5 mm or not greater than about 8.0 mm or not greater than about 7.5 mm or not greater than about 7.0 mm or not greater than about 6.5 mm or not greater than about 6.0 mm or not greater than about 5.5 mm or not greater than about 5.0 mm or not greater than about 4.5 mm or not greater than about 4.0 mm or not greater than about 3.5 mm or not greater than about 3.0 mm or not greater than about 2.5 mm or not greater than about 2.0 mm or not greater than about 1.5 mm or even not greater than about 1.0 mm. It will be appreciated that the thickness of the polyurethane foam may be within a range between any of the minimum and maximum values noted above. It will be further appreciated that the thickness of the polyurethane foam may be any value between any of the minimum and maximum values noted above.

Referring now to a particular use of the polyurethane foam formed according to embodiments described herein, a particular embodiment may include a battery compression pad that may include a polyurethane foam. It will be appreciated that the polyurethane foam of the battery compression pad may be formed according to any of the embodiments described herein. It will be further appreciated that the polyurethane foam of the battery compression pad may include any of the components described in reference to any of the embodiments described herein. It will be still further appreciated that the polyurethane foam of the battery compression pad may include any of the characteristics described in reference to embodiments described herein.

Many different aspects and embodiments are possible. Some of those aspects and embodiments are described herein. After reading this specification, skilled artisans will appreciate that those aspects and embodiments are only illustrative and do not limit the scope of the present invention. Embodiments may be in accordance with any one or more of the embodiments as listed below.

Embodiment 1. A polyurethane foam comprising: a first polyol component comprising a polyether polyol having a functionality of at least about 5; and a second polyol component comprising at least one component selected from the group of a polyether polyol having a functionality of not greater than about 4, and a polyester polyol having a functionality of not greater than about 4, wherein the polyurethane foam comprises a density of at least about 150 kg/m³, wherein the polyurethane foam comprises a compression curve ratio CFD_{70}/CFD_{10} of not greater than about 20, where CFD_{70} is equal to the compression force deflection (CFD) of the polyurethane foam measured at a 70% compression ratio and CFD_{10} is equal to the compression force deflection (CFD) of the polyurethane foam measured at a 10% compression ratio.

Embodiment 2. A polyurethane foam comprising: a first polyol component comprising a polyether polyol having a functionality of at least about 5; and a second polyol component comprising at least one component selected from the group of a polyether polyol having a functionality of not greater than about 4, and a polyester polyol having a functionality of not greater than about 4, wherein the polyurethane foam comprises a density of at least about 150 kg/m³, wherein the polyurethane foam comprises a HBF rating based on a UL94 flame retardancy test performed at a polyurethane foam thickness of 1 mm.

Embodiment 3. The polyurethane foam of embodiment 2, wherein the polyurethane foam comprises a compression curve ratio CFD_{70}/CFD_{10} of not greater than about 20, where CFD_{70} is equal to the compression force deflection

(CFD) of the polyurethane foam measured at a 70% compression ratio and CFD_{10} is equal to the compression force deflection (CFD) of the polyurethane foam measured at a 10% compression ratio.

Embodiment 4. The polyurethane foam of embodiment 1, wherein the polyurethane foam comprises a HBF rating based on a UL94 flame retardancy test performed at a polyurethane foam thickness of 1 mm.

Embodiment 5. The polyurethane foam of any one of embodiments 1, 2, 3, and 4, wherein the polyurethane foam comprises a CFD_{70} of at least about 200 KPa.

Embodiment 6. The polyurethane foam of any one of embodiments 1, 2, 3, and 4, wherein the polyurethane foam comprises a CFD_{70} of not greater than about 2500 KPa.

Embodiment 7. The polyurethane foam of any one of embodiments 1, 2, 3, and 4, wherein the polyurethane foam comprises a CFD_{10} of at least about 40 KPa.

Embodiment 8. The polyurethane foam of any one of embodiments 1, 2, 3, and 4, wherein the polyurethane foam comprises a CFD_{10} of not greater than about 120 KPa.

Embodiment 9. The polyurethane foam of any one of embodiments 1, 2, 3, and 4, wherein the polyurethane foam comprises a density of not greater than about 400 kg/m³.

Embodiment 10. The polyurethane foam of any one of embodiments 1, 2, 3, and 4, wherein the polyurethane foam comprises a density of not greater than about 330 kg/m³.

Embodiment 11. The polyurethane foam of any one of embodiments 1, 2, 3, and 4, wherein the first polyol component comprises an OH number of at least about 400 KOH mg/g.

Embodiment 12. The polyurethane foam of any one of embodiments 1, 2, 3, and 4, wherein the first polyol component comprises an OH number of not greater than about 450 KOH mg/g.

Embodiment 13. The polyurethane foam of any one of embodiments 1, 2, 3, and 4, wherein the first polyol component comprises a molecular mass of at least about 680 g/mol.

Embodiment 14. The polyurethane foam of any one of embodiments 1, 2, 3, and 4, wherein the first polyol component comprises a molecular mass of not greater than about 850 g/mol.

Embodiment 15. The polyurethane foam of any one of embodiments 1, 2, 3, and 4, wherein the first polyol component comprises a functionality of 5.

Embodiment 16. The polyurethane foam of any one of embodiments 1, 2, 3, and 4, wherein the first polyol component comprises a functionality of 6.

Embodiment 17. The polyurethane foam of any one of embodiments 1, 2, 3, and 4, wherein the first polyol component comprises a functionality of 7.

Embodiment 18. The polyurethane foam of any one of embodiments 1, 2, 3, and 4, wherein the first polyol component comprises a functionality of 8.

Embodiment 19. The polyurethane foam of any one of embodiments 1, 2, 3, and 4, wherein the polyurethane foam comprises first polyol component content of at least about 2 wt. % for a total weight of the polyurethane foam.

Embodiment 20. The polyurethane foam of any one of embodiments 1, 2, 3, and 4, wherein the polyurethane foam comprises a first polyol component content of not greater than about 10 wt. % for a total weight of the polyurethane foam.

Embodiment 21. The polyurethane foam of any one of embodiments 1, 2, 3, and 4, wherein the second polyol component comprises a polyether polyol having a functionality of not greater than about 4.

Embodiment 22. The polyurethane foam of any one of embodiments 1, 2, 3, and 4, wherein the second polyol component comprises a polyester polyol having a functionality of not greater than about 4.

Embodiment 23. The polyurethane foam of any one of embodiments 1, 2, 3, and 4, wherein the second polyol component comprises an OH number of at least about 250 KOH mg/g.

Embodiment 24. The polyurethane foam of any one of embodiments 1, 2, 3, and 4, wherein the second polyol component comprises an OH number of not greater than about 350 KOH mg/g.

Embodiment 25. The polyurethane foam of any one of embodiments 1, 2, 3, and 4, wherein the second polyol component comprises a molecular mass of at least about 500 g/mol.

Embodiment 26. The polyurethane foam of any one of embodiments 1, 2, 3, and 4, wherein the second polyol component comprises a molecular mass of not greater than about 650 g/mol.

Embodiment 27. The polyurethane foam of any one of embodiments 1, 2, 3, and 4, wherein the second polyol component comprises a functionality of 4.

Embodiment 28. The polyurethane foam of any one of embodiments 1, 2, 3, and 4, wherein the second polyol component comprises a functionality of 3.

Embodiment 29. The polyurethane foam of any one of embodiments 1, 2, 3, and 4, wherein the second polyol component comprises a functionality of 2.

Embodiment 30. The polyurethane foam of any one of embodiments 1, 2, 3, and 4, wherein the second polyol component comprises a functionality of 1.

Embodiment 31. The polyurethane foam of any one of embodiments 1, 2, 3, and 4, wherein the polyurethane foam comprises a second polyol component content of at least about 5.0 wt. % for a total weight of the polyurethane foam.

Embodiment 32. The polyurethane foam of any one of embodiments 1, 2, 3, and 4, wherein the polyurethane foam comprises a second polyol component content of not greater than about 15.0 wt. % for a total weight of the polyurethane foam.

Embodiment 33. The polyurethane foam of any one of embodiments 1, 2, 3, and 4, wherein the polyurethane foam further comprises a third polyol component.

Embodiment 34. The polyurethane foam of embodiment 33, wherein the third polyol component comprises an OH number of at least about 10 KOH mg/g.

Embodiment 35. The polyurethane foam of embodiment 33, wherein the third polyol component comprises an OH number of not greater than about 30 KOH mg/g.

Embodiment 36. The polyurethane foam of embodiment 33, wherein the third polyol component comprises a molecular mass of at least about 7000 g/mol.

Embodiment 37. The polyurethane foam of embodiment 33, wherein the third polyol component comprises a molecular mass of not greater than about 10000 g/mol.

Embodiment 38. The polyurethane foam of embodiment 33, wherein the third polyol component comprises a functionality of 4.

Embodiment 39. The polyurethane foam of embodiment 33, wherein the third polyol component comprises a functionality of 3.

Embodiment 40. The polyurethane foam of embodiment 33, wherein the third polyol component comprises a functionality of 2.

Embodiment 41. The polyurethane foam of embodiment 33, wherein the third polyol component comprises a functionality of 1.

Embodiment 42. The polyurethane foam of embodiment 33, wherein the polyurethane foam comprises a third polyol component content of at least about 5.0 wt. % for a total weight of the polyurethane foam.

Embodiment 43. The polyurethane foam of embodiment 33, wherein the polyurethane foam comprises a third polyol component content of not greater than about 25.0 wt. % for a total weight of the polyurethane foam.

Embodiment 44. The polyurethane foam of any one of embodiments 1, 2, 3, and 4, wherein the polyurethane foam comprises a catalyst.

Embodiment 45. The polyurethane foam of embodiment 44, wherein the polyurethane foam comprises a catalyst content of at least about 0.1 wt. % for a total weight of the polyurethane foam or at least about 0.25 wt. % or at least about 0.5 wt. % or at least about 0.75 wt. % or at least about 1.0 wt. % or at least about 1.25 wt. % or at least about 1.5 wt. %.

Embodiment 46. The polyurethane foam of embodiment 44, wherein the polyurethane foam comprises a catalyst content of not greater than about 5.0 wt. % for a total weight of the polyurethane foam or not greater than about 4.75 wt. % or not greater than about 4.5 wt. % or not greater than about 4.25 wt. % or not greater than about 4.0 wt. % or not greater than about 3.75 wt. % or not greater than about 3.5 wt. % or not greater than about 3.25 wt. % or not greater than about 3.0 wt. % or not greater than about 2.75 wt. % or not greater than about 2.5 wt. % or not greater than about 2.25 wt. % or not greater than about 2.0 wt. %.

Embodiment 47. The polyurethane foam of any one of embodiments 1, 2, 3, and 4, wherein the polyurethane foam comprises a pigment.

Embodiment 48. The polyurethane foam of embodiment 47, wherein the polyurethane foam comprises a pigment content of at least about 0.1 wt. % for a total weight of the polyurethane foam or at least about 0.25 wt. % or at least about 0.5 wt. % or at least about 0.75 wt. % or at least about 1.0 wt. % or at least about 1.25 wt. % or at least about 1.5 wt. %.

Embodiment 49. The polyurethane foam of embodiment 47, wherein the polyurethane foam comprises a pigment content of not greater than about 5.0 wt. % for a total weight of the polyurethane foam or not greater than about 4.75 wt. % or not greater than about 4.5 wt. % or not greater than about 4.25 wt. % or not greater than about 4.0 wt. % or not greater than about 3.75 wt. % or not greater than about 3.5 wt. % or not greater than about 3.25 wt. % or not greater than about 3.0 wt. % or not greater than about 2.75 wt. % or not greater than about 2.5 wt. % or not greater than about 2.25 wt. % or not greater than about 2.0 wt. %.

Embodiment 50. The polyurethane foam of any one of embodiments 1, 2, 3, and 4, wherein the polyurethane foam comprises a chain extender.

Embodiment 51. The polyurethane foam of embodiment 50, wherein the polyurethane foam comprises a chain extender content of at least about 0.1 wt. % for a total weight of the polyurethane foam or at least about 0.25 wt. % or at least about 0.5 wt. % or at least about 0.75 wt. % or at least about 1.0 wt. % or at least about 1.25 wt. % or at least about 1.5 wt. %.

Embodiment 52. The polyurethane foam of embodiment 50, wherein the polyurethane foam comprises a chain extender content of not greater than about 5.0 wt. % for a total weight of the polyurethane foam or not greater than

about 4.75 wt. % or not greater than about 4.5 wt. % or not greater than about 4.25 wt. % or not greater than about 4.0 wt. % or not greater than about 3.75 wt. % or not greater than about 3.5 wt. % or not greater than about 3.25 wt. % or not greater than about 3.0 wt. % or not greater than about 2.75 wt. % or not greater than about 2.5 wt. % or not greater than about 2.25 wt. % or not greater than about 2.0 wt. %.

Embodiment 53. The polyurethane foam of any one of embodiments 1, 2, 3, and 4, wherein the polyurethane foam comprises a thixotropic agent.

Embodiment 54. The polyurethane foam of embodiment 53, wherein the polyurethane foam comprises a thixotropic agent content of at least about 0.1 wt. % for a total weight of the polyurethane foam or at least about 0.25 wt. % or at least about 0.5 wt. % or at least about 0.75 wt. %.

Embodiment 55. The polyurethane foam of embodiment 53, wherein the polyurethane foam comprises a thixotropic agent content of not greater than about 4.0 wt. % for a total weight of the polyurethane foam or not greater than about 3.75 wt. % or not greater than about 3.5 wt. % or not greater than about 3.25 wt. % or not greater than about 3.0 wt. % or not greater than about 2.75 wt. % or not greater than about 2.5 wt. % or not greater than about 2.25 wt. % or not greater than about 2.0 wt. % or not greater than about 1.75 wt. % or not greater than about 1.5 wt. % or not greater than about 1.25 wt. % or not greater than about 1.0 wt. %.

Embodiment 56. The polyurethane foam of any one of embodiments 1, 2, 3, and 4, wherein the polyurethane foam comprises isocyanate.

Embodiment 57. The polyurethane foam of embodiment 56, wherein the polyurethane foam comprises an isocyanate content of at least about 8 wt. % for a total weight of the polyurethane foam or at least about 9 wt. % or at least about 10 wt. % or at least about 11 wt. % or at least about 12 wt. % or at least about 13 wt. % or at least about 14 wt. % or at least about 15 wt. %.

Embodiment 58. A method of forming a polyurethane foam comprising: providing a raw material mixture comprising: a raw first polyol component comprising a polyether polyol having a functionality of at least about 5; and a raw second polyol component comprising at least one component selected from the group of a polyether polyol having a functionality of not greater than about 4, and a polyester polyol having a functionality of not greater than about 4, and forming the raw material mixture into a polyurethane foam, wherein the polyurethane foam comprises a density of at least about 150 kg/m³, wherein the polyurethane foam comprises a compression curve ratio CFD₇₀/CFD₁₀ of not greater than about 20, where CFD₇₀ is equal to the compression force deflection (CFD) of the polyurethane foam measured at a 70% compression ratio and CFD₁₀ is equal to the compression force deflection (CFD) of the polyurethane foam measured at a 10% compression ratio.

Embodiment 59. A method of forming a polyurethane foam comprising: providing a raw material mixture comprising: a raw first polyol component comprising a polyether polyol having a functionality of at least about 5; and a raw second polyol component comprising at least one component selected from the group of a polyether polyol having a functionality of not greater than about 4, and a polyester polyol having a functionality of not greater than about 4, and forming the raw material mixture into a polyurethane foam, wherein the polyurethane foam comprises a density of at least about 150 kg/m³, wherein the polyurethane foam comprises a HBF rating based on a UL94 flame retardancy test performed at a polyurethane foam thickness of 1 mm.

Embodiment 60. The method of embodiment 59, wherein the polyurethane foam comprises a compression curve ratio CFD₇₀/CFD₁₀ of not greater than about 20, where CFD₇₀ is equal to the compression force deflection (CFD) of the polyurethane foam measured at a 70% compression ratio and CFD₁₀ is equal to the compression force deflection (CFD) of the polyurethane foam measured at a 10% compression ratio.

Embodiment 61. The method of embodiment 58, wherein the polyurethane foam comprises a HBF rating based on a UL94 flame retardancy test performed at a polyurethane foam thickness of 1 mm.

Embodiment 62. The method of any one of embodiments 58, 59, 60, and 61, wherein the polyurethane foam comprises a CFD₇₀ of at least about 200 KPa.

Embodiment 63. The method of any one of embodiments 58, 59, 60, and 61, wherein the polyurethane foam comprises a CFD₇₀ of not greater than about 2500 KPa.

Embodiment 64. The method of any one of embodiments 58, 59, 60, and 61, wherein the polyurethane foam comprises a CFD₁₀ of at least about 40 KPa.

Embodiment 65. The method of any one of embodiments 58, 59, 60, and 61, wherein the polyurethane foam comprises a CFD₁₀ of not greater than about 250 KPa.

Embodiment 66. The method of any one of embodiments 58, 59, 60, and 61, wherein the polyurethane foam comprises a density of not greater than about 400 kg/m³.

Embodiment 67. The method of any one of embodiments 58, 59, 60, and 61, wherein the polyurethane foam comprises a density of not greater than about 330 kg/m³.

Embodiment 68. The method of any one of embodiments 58, 59, 60, and 61, wherein the first polyol component comprises an OH number of at least about 400 KOH mg/g.

Embodiment 69. The method of any one of embodiments 58, 59, 60, and 61, the raw first polyol component comprises an OH number of not greater than about 450 KOH mg/g.

Embodiment 70. The method of any one of embodiments 58, 59, 60, and 61, wherein the raw first polyol component comprises a molecular mass of at least about 680 g/mol.

Embodiment 71. The method of any one of embodiments 58, 59, 60, and 61, wherein the raw first polyol component comprises a molecular mass of not greater than about 850 g/mol.

Embodiment 72. The method of any one of embodiments 58, 59, 60, and 61, wherein the raw first polyol component comprises a functionality of 5.

Embodiment 73. The method of any one of embodiments 58, 59, 60, and 61, wherein the raw first polyol component comprises a functionality of 6.

Embodiment 74. The method of any one of embodiments 58, 59, 60, and 61, wherein the raw first polyol component comprises a functionality of 7.

Embodiment 75. The method of any one of embodiments 58, 59, 60, and 61, wherein the raw first polyol component comprises a functionality of 8.

Embodiment 76. The method of any one of embodiments 58, 59, 60, and 61, wherein the raw material mixture comprises raw first polyol component content of at least about 2 wt. % for a total weight of the raw material mixture.

Embodiment 77. The method of any one of embodiments 58, 59, 60, and 61, wherein the raw material mixture comprises a raw first polyol component content of not greater than about 10 wt. % for a total weight of the raw material mixture.

Embodiment 78. The method of any one of embodiments 58, 59, 60, and 61, wherein the raw second polyol component comprises a polyether polyol having a functionality of not greater than about 4.

Embodiment 79. The method of any one of embodiments 58, 59, 60, and 61, wherein the raw second polyol component comprises a polyester polyol having a functionality of not greater than about 4.

Embodiment 80. The method of any one of embodiments 58, 59, 60, and 61, wherein the raw second polyol component comprises an OH number of at least about 250 KOH mg/g.

Embodiment 81. The method of any one of embodiments 58, 59, 60, and 61, wherein the raw second polyol component comprises an OH number of not greater than about 350 KOH mg/g.

Embodiment 82. The method of any one of embodiments 58, 59, 60, and 61, wherein the raw second polyol component comprises a molecular mass of at least about 500 g/mol.

Embodiment 83. The method of any one of embodiments 58, 59, 60, and 61, wherein the raw second polyol component comprises a molecular mass of not greater than about 650 g/mol.

Embodiment 84. The method of any one of embodiments 58, 59, 60, and 61, wherein the raw second polyol component comprises a functionality of 4.

Embodiment 85. The method of any one of embodiments 58, 59, 60, and 61, wherein the raw second polyol component comprises a functionality of 3.

Embodiment 86. The method of any one of embodiments 58, 59, 60, and 61, wherein the raw second polyol component comprises a functionality of 2.

Embodiment 87. The method of any one of embodiments 58, 59, 60, and 61, wherein the raw second polyol component comprises a functionality of 1.

Embodiment 88. The method of any one of embodiments 58, 59, 60, and 61, wherein the raw material mixture comprises a raw second polyol component content of at least about 5.0 wt. % for a total weight of the raw material mixture.

Embodiment 89. The method of any one of embodiments 58, 59, 60, and 61, wherein the raw material mixture comprises a raw second polyol component content of not greater than about 15.0 wt. % for a total weight of the raw material mixture.

Embodiment 90. The method of any one of embodiments 58, 59, 60, and 61, wherein the raw material mixture further comprises a raw third polyol component.

Embodiment 91. The method of embodiment 90, wherein the raw third polyol component comprises an OH number of at least about 10 KOH mg/g.

Embodiment 92. The method of embodiment 90, wherein the raw third polyol component comprises an OH number of not greater than about 30 KOH mg/g.

Embodiment 93. The method of embodiment 90, wherein the raw third polyol component comprises a molecular mass of at least about 7000 g/mol.

Embodiment 94. The method of embodiment 90, wherein the raw third polyol component comprises a molecular mass of not greater than about 10000 g/mol.

Embodiment 95. The method of embodiment 90, wherein the raw third polyol component comprises a functionality of 4.

Embodiment 96. The method of embodiment 90, wherein the raw third polyol component comprises a functionality of 3.

Embodiment 97. The method of embodiment 90, wherein the raw third polyol component comprises a functionality of 2.

Embodiment 98. The method of embodiment 90, wherein the raw third polyol component comprises a functionality of 1.

Embodiment 99. The method of embodiment 90, wherein the raw material mixture comprises a raw third polyol component content of at least about 5.0 wt. % for a total weight of the raw material mixture.

Embodiment 100. The method of embodiment 90, wherein the raw material mixture comprises a raw third polyol component content of not greater than about 25.0 wt. % for a total weight of the raw material mixture.

Embodiment 101. The method of any one of embodiments 58, 59, 60, and 61, wherein the raw material mixture comprises a raw catalyst.

Embodiment 102. The method of embodiment 101, wherein the raw material mixture comprises a raw catalyst content of at least about 0.1 wt. % for a total weight of the raw material mixture or at least about 0.25 wt. % or at least about 0.5 wt. % or at least about 0.75 wt. % or at least about 1.0 wt. % or at least about 1.25 wt. % or at least about 1.5 wt. %.

Embodiment 103. The method of embodiment 101, wherein the raw material mixture comprises a raw catalyst content of not greater than about 5.0 wt. % for a total weight of the raw material mixture or not greater than about 4.75 wt. % or not greater than about 4.5 wt. % or not greater than about 4.25 wt. % or not greater than about 4.0 wt. % or not greater than about 3.75 wt. % or not greater than about 3.5 wt. % or not greater than about 3.25 wt. % or not greater than about 3.0 wt. % or not greater than about 2.75 wt. % or not greater than about 2.5 wt. % or not greater than about 2.25 wt. % or not greater than about 2.0 wt. %.

Embodiment 104. The method of any one of embodiments 58, 59, 60, and 61, wherein the raw material mixture comprises a raw pigment.

Embodiment 105. The method of embodiment 104, wherein the raw material mixture comprises a raw pigment content of at least about 0.1 wt. % for a total weight of the raw material mixture or at least about 0.25 wt. % or at least about 0.5 wt. % or at least about 0.75 wt. % or at least about 1.0 wt. % or at least about 1.25 wt. % or at least about 1.5 wt. %.

Embodiment 106. The method of embodiment 104, wherein the raw material mixture comprises a raw pigment content of not greater than about 5.0 wt. % for a total weight of the raw material mixture or not greater than about 4.75 wt. % or not greater than about 4.5 wt. % or not greater than about 4.25 wt. % or not greater than about 4.0 wt. % or not greater than about 3.75 wt. % or not greater than about 3.5 wt. % or not greater than about 3.25 wt. % or not greater than about 3.0 wt. % or not greater than about 2.75 wt. % or not greater than about 2.5 wt. % or not greater than about 2.25 wt. % or not greater than about 2.0 wt. %.

Embodiment 107. The method of any one of embodiments 58, 59, 60, and 61, wherein the raw material mixture comprises a raw chain extender.

Embodiment 108. The method of embodiment 107, wherein the raw material mixture comprises a raw chain extender content of at least about 0.1 wt. % for a total weight of the raw material mixture or at least about 0.25 wt. % or at least about 0.5 wt. % or at least about 0.75 wt. % or at least about 1.0 wt. % or at least about 1.25 wt. % or at least about 1.5 wt. %.

Embodiment 109. The method of embodiment 107, wherein the raw material mixture comprises a raw chain extender content of not greater than about 5.0 wt. % for a total weight of the raw material mixture or not greater than about 4.75 wt. % or not greater than about 4.5 wt. % or not greater than about 4.25 wt. % or not greater than about 4.0 wt. % or not greater than about 3.75 wt. % or not greater than about 3.5 wt. % or not greater than about 3.25 wt. % or not greater than about 3.0 wt. % or not greater than about 2.75 wt. % or not greater than about 2.5 wt. % or not greater than about 2.25 wt. % or not greater than about 2.0 wt. %.

Embodiment 110. The method of any one of embodiments 58, 59, 60, and 61, wherein the raw material mixture comprises a raw thixotropic agent.

Embodiment 111. The method of embodiment 110, wherein the raw material mixture comprises a raw thixotropic agent content of at least about 0.1 wt. % for a total weight of the raw material mixture or at least about 0.25 wt. % or at least about 0.5 wt. % or at least about 0.75 wt. %.

Embodiment 112. The method of embodiment 110, wherein the raw material mixture comprises a raw thixotropic agent content of not greater than about 4.0 wt. % for a total weight of the raw material mixture or not greater than about 3.75 wt. % or not greater than about 3.5 wt. % or not greater than about 3.25 wt. % or not greater than about 3.0 wt. % or not greater than about 2.75 wt. % or not greater than about 2.5 wt. % or not greater than about 2.25 wt. % or not greater than about 2.0 wt. % or not greater than about 1.75 wt. % or not greater than about 1.5 wt. % or not greater than about 1.25 wt. % or not greater than about 1.0 wt. %.

Embodiment 113. The method of any one of embodiments 58, 59, 60, and 61, wherein the raw material mixture comprises raw isocyanate.

Embodiment 114. The method of embodiment 113, wherein the raw material mixture comprises a raw isocyanate content of at least about 8 wt. % for a total weight of the raw material mixture or at least about 9 wt. % or at least about 10 wt. % or at least about 11 wt. % or at least about 12 wt. % or at least about 13 wt. % or at least about 14 wt. % or at least about 15 wt. %.

EXAMPLES

The concepts described herein will be further described in the following Examples, which do not limit the scope of the invention described in the claims.

Example 1

A sample polyurethane foam S1 was formed according to embodiments described herein. The composition of sample polyurethane foam S1 is summarized in Table 1 below.

TABLE 1

Sample Foam Composition	
Component	S1 (wt. % for a total weight of the sample)
First Polyol	5.87
Second Polyol (Polyether)	8.39
Third Polyol	16.78
Fourth Polyol	25.17
Catalyst	1.34
Pigment	1.68
Chain extender	1.34
Filler	10.07
Isocyanate	27.68

The sample polyurethane foam was formed by mixing all the liquid components (including the first polyol, second polyol, third polyol, fourth polyol, surfactant, catalyst, pigment, chain extender) until the liquid phase is homogeneous. Then, any fillers were added to the liquid mixture. The combined mixture was then mixed until it reached a homogeneous composition. Finally, the isocyanate was added to the combined mixture. The final mixture was cured in an oven at 170° C. for several minutes.

The sample polyurethane foam was tested to determine the compression force deflection (CFD) of the polyurethane foam measured at a 70% compression ratio, the compression force deflection (CFD) of the polyurethane foam measured at a 10% compression ratio, a compression curve ratio CFD_{70}/CFD_{10} .

TABLE 2

Compression Force Deflection and Compression Curve Ratio	
Property	S1
Density (kg/m ³)	320
CFD ₁₀	87.5
CFD ₇₀	1342.4
CFD ₇₀ /CFD ₁₀	15.34

Note that not all of the activities described above in the general description or the examples are required, that a portion of a specific activity may not be required, and that one or more further activities may be performed in addition to those described. Still further, the order in which activities are listed is not necessarily the order in which they are performed.

Benefits, other advantages, and solutions to problems have been described above with regard to specific embodiments. However, the benefits, advantages, solutions to problems, and any feature(s) that may cause any benefit, advantage, or solution to occur or become more pronounced are not to be construed as a critical, required, or essential feature of any or all the claims.

The specification and illustrations of the embodiments described herein are intended to provide a general understanding of the structure of the various embodiments. The specification and illustrations are not intended to serve as an exhaustive and comprehensive description of all of the elements and features of apparatus and systems that use the structures or methods described herein. Separate embodiments may also be provided in combination in a single embodiment, and conversely, various features that are, for brevity, described in the context of a single embodiment, may also be provided separately or in any subcombination. Further, reference to values stated in ranges includes each and every value within that range. Many other embodiments may be apparent to skilled artisans only after reading this specification. Other embodiments may be used and derived from the disclosure, such that a structural substitution, logical substitution, or another change may be made without departing from the scope of the disclosure. Accordingly, the disclosure is to be regarded as illustrative rather than restrictive.

What is claimed is:

1. A polyurethane foam comprising:
 - a first polyol component comprising a polyether polyol having a functionality of at least about 5; and
 - a second polyol component comprising at least one component selected from the group of a polyether polyol

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- having a functionality of not greater than about 4 and a polyester polyol having a functionality of not greater than about 4,
- wherein the first polyol component comprises an OH number of at least about 400 KOH mg/g and not greater than about 450 KOH mg/g,
- wherein the polyurethane foam comprises a density of at least about 150 kg/m^3 , and
- wherein the polyurethane foam comprises a compression curve ratio $\text{CFD}_{70}/\text{CFD}_{10}$ of not greater than about 20, where CFD_{70} is equal to the compression force deflection (CFD) of the polyurethane foam measured at a 70% compression ratio and CFD_{10} is equal to the compression force deflection (CFD) of the polyurethane foam measured at a 10% compression ratio.
2. The polyurethane foam of claim 1, wherein the polyurethane foam comprises a HBF rating based on a UL94 flame retardancy test performed at a polyurethane foam thickness of 1 mm.
3. The polyurethane foam of claim 1, wherein the polyurethane foam comprises a CFD_{70} of at least about 200 KPa and not greater than about 2500 KPa.
4. The polyurethane foam of claim 1, wherein the polyurethane foam comprises a CFD_{10} of at least about 40 KPa and not greater than about 250 KPa.
5. The polyurethane foam of claim 1, wherein the polyurethane foam comprises a density of not greater than about 400 kg/m^3 .
6. The polyurethane foam of claim 1, wherein the first polyol component comprises a molecular mass of at least about 680 g/mol and not greater than about 850 g/mol.
7. The polyurethane foam of claim 1, wherein the polyurethane foam comprises first polyol component content of at least about 2 wt. % and not greater than about 10 wt. % for a total weight of the polyurethane foam.
8. The polyurethane foam of claim 1, wherein the second polyol component comprises an OH number of at least about 250 KOH mg/g and not greater than about 350 KOH mg/g.
9. The polyurethane foam of claim 1, wherein the second polyol component comprises a molecular mass of at least about 500 g/mol and not greater than about 650 g/mol.
10. The polyurethane foam of claim 1, wherein the polyurethane foam comprises a second polyol component content of at least about 5.0 wt. % and not greater than about 15.0 wt. % for a total weight of the polyurethane foam.
11. The polyurethane foam of claim 1, wherein the polyurethane foam further comprises a third polyol component.
12. A polyurethane foam comprising:
 a first polyol component comprising a polyether polyol having a functionality of at least about 5; and
 a second polyol component comprising at least one component selected from the group of a polyether polyol having a functionality of not greater than about 4 and a polyester polyol having a functionality of not greater than about 4,

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- wherein the first polyol component comprises an OH number of at least about 400 KOH mg/g and not greater than about 450 KOH mg/g,
- wherein the polyurethane foam comprises a density of at least about 150 kg/m^3 , and
- wherein the polyurethane foam comprises a HBF rating based on a UL94 flame retardancy test performed at a polyurethane foam thickness of 1 mm.
13. The polyurethane foam of claim 12, wherein the polyurethane foam comprises a compression curve ratio $\text{CFD}_{70}/\text{CFD}_{10}$ of not greater than about 20, where CFD_{70} is equal to the compression force deflection (CFD) of the polyurethane foam measured at a 70% compression ratio and CFD_{10} is equal to the compression force deflection (CFD) of the polyurethane foam measured at a 10% compression ratio.
14. The polyurethane foam of claim 12, wherein the polyurethane foam comprises a CFD_{70} of at least about 200 KPa and not greater than about 2500 KPa.
15. The polyurethane foam of claim 12, wherein the polyurethane foam comprises a CFD_{10} of at least about 40 KPa and not greater than about 250 KPa.
16. The polyurethane foam of claim 12, wherein the polyurethane foam comprises first polyol component content of at least about 2 wt. % and not greater than about 10 wt. % for a total weight of the polyurethane foam.
17. The polyurethane foam of claim 12, wherein the polyurethane foam comprises a second polyol component content of at least about 5.0 wt. % and not greater than about 15.0 wt. % for a total weight of the polyurethane foam.
18. The polyurethane foam of claim 12, wherein the polyurethane foam further comprises a third polyol component.
19. A method of forming a polyurethane foam comprising:
 providing a raw material mixture comprising:
 a raw first polyol component comprising a polyether polyol having a functionality of at least about 5; and
 a raw second polyol component comprising at least one component selected from the group of a polyether polyol having a functionality of not greater than about 4 and a polyester polyol having a functionality of not greater than about 4, and
 forming the raw material mixture into a polyurethane foam,
 wherein the first polyol component comprises an OH number of at least about 400 KOH mg/g and not greater than about 450 KOH mg/g,
 wherein the polyurethane foam comprises a density of at least about 150 kg/m^3 , and
 wherein the polyurethane foam comprises a compression curve ratio $\text{CFD}_{70}/\text{CFD}_{10}$ of not greater than about 20, where CFD_{70} is equal to the compression force deflection (CFD) of the polyurethane foam measured at a 70% compression ratio and CFD_{10} is equal to the compression force deflection (CFD) of the polyurethane foam measured at a 10% compression ratio.

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